

ZIRCONIA CROWNS VERSUS PRE-VENEERED STAINLESS STEEL CROWNS IN PRIMARY ANTERIOR TEETH: A RETROSPECTIVE STUDY OF CLINICAL PERFORMANCE AND PARENTAL SATISFACTION

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ABSTRACT

Purpose: This study aimed at evaluating the clinical performance and parental satisfaction with zirconia crowns versus the pre-veneered stainless-steel crowns (SSCs) in primary anterior maxillary teeth in a group of Egyptian children under general anesthesia.

Methods: A retrospective analysis of forty maxillary anterior pediatric zirconia crowns versus forty pre-veneered SSCs was performed. Crowns were examined for retention, gingival health, color match, contour and opposing tooth wear. Parental satisfaction with either type of crowns was evaluated by questionnaire.

Results: Seventy-seven crowns were evaluated in 32 children with 3 teeth lost to exfoliation. Crowns were examined 4-12 months after placement. Zirconia crowns showed a 100% retentiveness, color match, absence of gingival irritation, 94.7% cosmetic appearance with 100% overall parental satisfaction rated as very satisfied. On the other hand, although pre-veneered SSCs showed 94.9% retentiveness, 12.8% (n=5) showed mild inflammation on the gingival index together with slight shade mismatch, along with 23.1% (n=9) non-ideal crowns with a reduced overall parental satisfaction rated as 71.8% very satisfied.

Conclusions: Pediatric zirconia crowns offer a better esthetic and highly acceptable, albeit more expensive, restorative option for primary maxillary anterior teeth.

Keywords: Zirconia crown, Pre-veneered SSCs, Primary anterior teeth, early childhood caries.

INTRODUCTION

Despite the reduced incidence of caries in children owing to the advances in preventive dentistry field and community-fluoridated water, together with the

increased dental education, still early childhood caries (ECC) represents a global health problem (Shuman I, 2016). This comprises the early carious involvement of the primary maxillary incisors, then

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the maxillary and mandibular first primary molars followed by the mandibular cuspids (**Wayne, 2001**).

It is mandatory to restore these carious primary teeth to preserve their integrity until the eruption of permanent teeth (**Mendes et al., 2004**). When the lesion is too large to restore with a direct restoration, a preformed pediatric crown is indicated. However, restoration of carious primary anterior teeth might be a challenging procedure due to their small size, close proximity of pulp and relatively thin enamel leading to a reduced surface area for bonding, not to mention issues related to child behavior and cost of treatment (**Donly, 2002; Usha et al., 2007**).

Moreover, parents have become more demanding of esthetic restorations and are more engaged in the clinical decision-making process making the esthetic management of primary teeth a fundamental need (**Salami et al., 2015**). In addition, in their study, Fishman and colleagues reported that children themselves choose tooth-colored restorations, tooth-colored composite material was the most preferred restoration among children while silver-colored amalgam was the least preferred restoration (**Fishman et al., 2006**).

In order to restore primary anterior teeth, the American Academy of Pediatric Dentistry (AAPD) concluded, based on expert opinion and on the little scientific support for any of the utilized clinical techniques in the cases of multi-surface lesions, that stainless steel crowns (SSCs), resin composite strip crowns, open-faced SSCs and more recently pre-veneered SSCs should be proposed as treatment options for full-coronal coverage restorations (**AAPD, 2016**).

These restorations have their merits and drawbacks. Resin strip crowns have been arguably the most esthetic option, as the color and shape can be controlled; however, they require adequate

isolation and are technique sensitive (**Kupietzky, 2002**). As to the open-faced crowns, they are more moisture tolerant for cementation though they have little literature supporting their use, besides the composite facing is liable to detachment (**Waggoner & Cohen, 1995**).

SSCs are known to be the most protective and durable restorations of the primary dentition (**Seale & Randall, 2015**). The placement of these preformed metal crowns is effortless and time-efficient. However, despite the superior qualities of these crowns, their use is not quite popular among dental practitioners in clinical practice, owing to their poor esthetic appearance (**Threlfall et al., 2005**).

Efforts have been dedicated to develop esthetically acceptable crowns, that's when pre-veneered crowns appeared on the market. These are metal crowns with mechanically or chemically bonded esthetic material that covers the surfaces of the crown. Pre-veneered crowns do not require as much isolation as strip crowns, they can be cemented with a more moisture-tolerant glass ionomer cement (**MacLean et al., 2007**). These crowns combine the durability of SSCs along with the esthetics of a resin facing. They have been described in the literature for restoration of both anterior and posterior primary teeth (**Innes et al., 2015**).

The clinical data as well as the parental satisfaction for these crowns are excellent, nevertheless, long-term follow-ups have revealed some drawbacks among which the frequent fracturing of the esthetic material when preformed pre-veneered crowns are used to restore primary molars (**Kratunova & O'Connell, 2014; O'Connell et al., 2014**) together with the limited crimp-ability that requires greater removal of tooth structure (**Shuman I, 2016**).

A breakthrough in crown & bridge frameworks occurred in 2001, when Suttor et al. proposed the

use of prefabricated zirconia oxide (**Suttor et al., 2001**). Since then, zirconia crowns proved to be successful for application in adult dentistry (**Al-Amleh et al., 2010; Zarone et al., 2011**). In 2008, pediatric zirconia crowns were developed. These crowns are preformed and made completely with ceramic materials (tetragonal zirconia). Pediatric zirconia crowns provided a more durable and esthetic alternative for the management of dental caries in primary molars (**Planells del pozo & Fuks, 2014**). Indeed, short term in vivo and in vitro studies suggested zirconia to be an acceptable restorative material in primary teeth (**Ashima et al., 2014; Townsend et al., 2014**).

Zirconia crowns offer full coverage of the treated tooth, premium esthetics, absence of materials that might detach, and potentially a less sensitive technique for cementation compared to a resin strip crown. However, disadvantages do exist for this type of restoration, albeit less, among which is the inability to crimp the crown for mechanical retention, zirconia crowns must be prefabricated with specific attributes, no chance for color change, moreover, zirconia crowns are also more expensive (**Clark et al., 2016**).

Despite the introduction of pediatric zirconia crowns in dental practice for almost a decade now, still clinical information about the performance of zirconia crowns compared to the esthetically acceptable pre-veneered crowns is scarce. To date, only one clinical study evaluated the clinical outcomes, and another evaluated the parental satisfaction of zirconia crowns versus pre-veneered SSCs in primary maxillary anterior teeth in children (**Walia et al., 2014; Salami et al., 2015**).

Clinical data about the performance of zirconia crowns versus pre-veneered SSCs for restoration of primary maxillary anterior teeth among Egyptian

children is still lacking, specially that zirconia crowns are more expensive than other types of crowns. Taken together, this retrospective study aimed at clinically evaluating the performance of zirconia crowns versus the pre-veneered SSCs in primary anterior maxillary teeth in a group of Egyptian children under general anesthesia as well as reporting the parental satisfaction regarding both types of crowns.

METHODS

Thirty-eight patients two- to six-year-old who had been treated at the Pediatric Dentistry department, Faculty of Dentistry, Cairo University, and received pre-veneered maxillary anterior restorations (NuSmile® S, Texas, USA) or Zirconia crowns (NuSmile® ZR, Texas, USA) were identified from the patient records for possible inclusion in the study. The study consisted of a clinical examination of the child and the administration of a questionnaire to the parent or guardian regarding his/her perception of either the pre-veneered or zirconia crown. Parents of 32 children were able to be contacted, and the children were scheduled for their routine care appointment. Consent was obtained from each participant's parent/guardian during the child's appointment. Excluded were children with systemic illness and special needs. All the restorations were placed under ideal conditions while the children were being treated in the operating room with the aid of general anesthesia due to the amount of dental treatment required and their inability to cooperate in a traditional dental setting.

Half of the children in this cross-sectional study had ECC and received pre-veneered maxillary anterior crowns, the other half had ECC and received zirconia maxillary anterior crowns placed by a pediatric dentistry faculty member. Subjects had at least three crowns cemented on primary maxillary incisors with glass ionomer cement (Ketac, 3M ESPE, St. Paul, Minn., USA) at least

four months prior to evaluation. One examiner completed all clinical evaluations and administered a written parental questionnaire. The examiner was available for questions from the parents regarding the questionnaire. This examiner was calibrated in the first three examination sessions with one faculty member during the clinical evaluation of the crowns for consistency of chairside clinical assessment. The examiner and faculty member each evaluated the patients independently and reviewed their scoring after the examination was complete (**Champagne et al., 2007**). For all three sessions, the examiner and faculty member were in 100 percent agreement.

Crowns were examined clinically and photographed to document the clinical appearance. All information regarding the child and the status of the crowns were recorded on a clinical data form. Data collected on the child included age, sex, and Gingival Score (**Shah et al., 2004**). The Gingival Score was: 0 = no inflammation; 1 = mild inflammation; 2 = moderate inflammation; 3 = marked inflammation. Each restoration was evaluated as follows: tooth exfoliation, crown retention, color match, crown contour, and opposing tooth wear. Each of these criteria was assessed and scored according to the scales illustrated in Table 1 (**Walia et al., 2014; Holsinger et al., 2016**). Color stability was assessed using one crown from the original kit as a standard compared to each individual restoration for color comparison.

Parents of the children participated in a survey designed to evaluate their satisfaction of the restorations. Parents were asked to score parameters such as the crown's color, size, shape, durability, child satisfaction and their overall satisfaction using a five-point Likert scale with 1 being very unsatisfied and 5 being very satisfied as illustrated in Table 1 (**Roberts et al., 2001; Salami et al., 2015**). Parents were also given the opportunity to make comments regarding the restorations.

TABLE (1) Clinical outcomes of primary maxillary anterior pre-veneered/zirconia crowns

Tooth exfoliated	
Yes	0
No	1
Crown Retention	
Intact	0
Chipped/small but noticeable areas of loss of material	1
Large loss of material	2
Complete loss of crown	3
Gingival index	
No inflammation	0
Mild inflammation	1
Moderate inflammation	2
Marked inflammation	3
Color match	
No noticeable difference from adjacent teeth	0
Slight shade mismatch	1
Obvious shade mismatch	2
Crown contour	
Crown is cosmetic, natural looking	0
Size/shape is acceptable, not ideal	1
Crown not esthetic, detracts from appearance of mouth	2
Opposing wear	
No wear	0
wear	1

RESULTS

Thirty-two children, who received either pre-veneered SSCs or zirconia crowns, were contacted and scheduled for a routine care appointment. A total of 80 crowns were identified, 40 pre-veneered SSCs and 40 zirconia pediatric crowns. Three teeth were lost to exfoliation, 1 from the pre-veneered SSCs group and 2 from the zirconia pediatric crowns group. At the time of examination, the crown age ranged from 4 months to 12 months after placement. Descriptive statistics were computed for the data including frequencies and percentages for the clinical outcomes and mean \pm SD for the parental satisfaction survey. Statistical analysis was

performed with IBM® SPSS® Statistics Version 22 for Windows. Data analysis was performed using the Fisher's exact test and significance level was set at $p \leq 0.05$.

As illustrated in table 2, clinical outcomes are reported as frequencies. Small but noticeable areas of loss of material was observed in 5% ($n=2$) of pre-veneered SSCs compared to 100% intact zirconia crowns (p -value >0.05 , Fisher's Exact test). As to the gingival index and color match, 12.8% ($n=5$ each) of pre-veneered SSCs showed mild inflammation & slight shade mismatch compared to 100% no inflammation or shade mismatch in zirconia crowns (p -value >0.05 , Fisher's Exact test). Regarding the crown contour, 23.1% ($n=9$) of pre-veneered SSCs were not ideal in shape/size compared to 5.3% ($n=2$) in zirconia crowns (p -value <0.05 , Fisher's Exact test). Evaluation of tooth wear on opposing teeth was done according to the Smith and Knight Tooth Wear Index (**Smith and Knight, 1984; Bardsley, 2008**). The incisal and labial surfaces of the teeth opposing the full-coronal restorations were clinically observed for any sign of

abrasion. Three (3.9%) of zirconia crowns showed signs of wear on opposing teeth, while no signs of wear were observed on opposing teeth for any of the pre-veneered crowns (p -value >0.05 , Fisher's Exact test).

As depicted in figure 1, a patient with non-ideal pre-veneered SSCs at 9 months follow-up, where gingival inflammation could be noted (black arrows) together with metal appearance in the lateral incisors. Figure 2 depicts a patient with a clinically and esthetically acceptable zirconia crowns at 12 months follow-up.

Most parents of the 32 children were very satisfied with the color (89.7%), size (87.2%), retention (92.3%) and durability (94.4%) of pre-veneered SSCs compared to 100% satisfaction with the color, retention, durability of zirconia crowns & 94.7% satisfaction with the size of these crowns. 97.4% of parents were very satisfied with the shape of zirconia crowns compared to 69.2% in pre-veneered SSCs group. 94.7% of parents rated the overall satisfaction as very satisfied with the zirconia crowns compared to 71.8% in pre-veneered SSCs group.

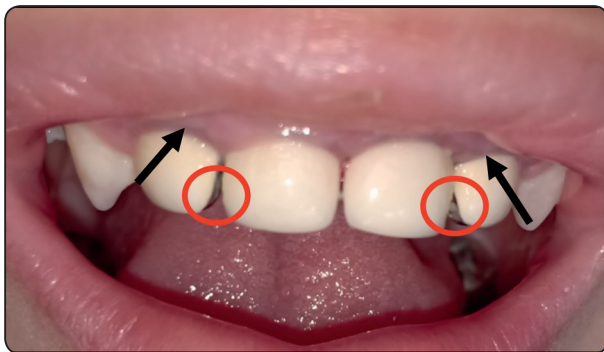


Fig. (1): Nine-months follow-up for Pre-veneered SSCs, showing gingival inflammation (black arrows) and metal appearance (red circles)



Fig. (2): One year follow-up for clinically and esthetically acceptable Zirconia crowns.

TABLE (2) Comparison of clinical outcomes of primary maxillary anterior Pre-veneered/Zirconia crowns

	Pre-veneered SSCs	Zirconia crowns
Tooth exfoliated	N (%)	N (%)
Yes	1 (2.5)	2 (5)
No	39 (97.5)	38 (95)
Crown Retention		
Intact	37 (94.9)	38 (100)
Chipped/small but noticeable areas of loss of material	2 (5.1)	0 (0)
Large loss of material	0 (0)	0 (0)
Complete loss of crown	0 (0)	0 (0)
Gingival index		
No inflammation	34 (87.2)	38 (100)
Mild inflammation	5 (12.8)	0 (0)
Moderate inflammation	0 (0)	0 (0)
Marked inflammation	0 (0)	0 (0)
Color match		
No noticeable difference from adjacent teeth	34 (87.2)	38 (100)
Slight shade mismatch	5 (12.8)	0 (0)
Obvious shade mismatch	0 (0)	0 (0)
Crown contour		
Crown is cosmetic, natural looking	30 (76.9)	36 (94.7)
Size/shape is acceptable, not ideal	9 (23.1)	2 (5.3)
Crown not esthetic, detracts from appearance of mouth	0 (0)	0 (0)
Opposing wear		
No wear	39 (100)	35 (92.1)
wear	0 (0)	3 (3.9)

TABLE (3) Comparison of mean parental satisfaction between the two groups; Pre-veneered SSC and Zirconia crowns.

Variables	Groups	Mean±SD
Color	Pre-veneered SSC	4.67±1.009
	Zirconia Crown	4.97±0.162
Size	Pre-veneered SSC	4.62±1.091
	Zirconia Crown	4.84±0.679
Shape	Pre-veneered SSC	4.26±1.208
	Zirconia Crown	4.92±0.487
Retention	Pre-veneered SSC	4.77±0.902
	Zirconia Crown	4.97±0.162
Durability	Pre-veneered SSC	4.92±0.354
	Zirconia Crown	4.97±0.162
Child Satisfaction	Pre-veneered SSC	4.67±0.701
	Zirconia Crown	4.97±0.162
Overall Satisfaction	Pre-veneered SSC	4.51±0.914
	Zirconia Crown	4.84±0.679

DISCUSSION

The “triangle of agreement” is an important factor when selecting a pediatric crown, this concept implies that the clinician, parent and child (when able) should decide together the best course of treatment when placing full-coverage crowns on primary teeth. In today’s cosmetically oriented society both parents and children do care about the esthetics of their teeth (**Peretz and Ram, 2002**). Moreover, oral disfigurement can negatively alter a child’s normal psychological development, leading to emotional and behavioral difficulties that typically result in diminished self-esteem, that’s why it is mandatory to correct the primary tooth back to a healthy state in both function and appearance (**Shuman I, 2016**).

Since the introduction of zirconia crowns for pediatric dental patients, both the pre-veneered SSCs and zirconia crowns became the most acceptable and esthetic options for restoration of primary teeth, however, only one study compared the performance of both types of crowns along with composite strip crowns in primary anterior teeth (**Walia et al., 2014**), and so, this study was designed to further compare the clinical performance and parental satisfaction of both crowns on anterior primary maxillary teeth in children under general anesthesia.

Pre-veneered SSCs have been one of the popular and acceptable esthetic options for the pediatric dentist, they also have high parental acceptance (**Roberts et al., 2001; Shah et al., 2004**). These crowns carry the advantage of being less sensitive to hemorrhage and moisture during placement. Although pre-veneered crowns are more expensive than stainless steel, composite strip and polycarbonate crowns, nevertheless, they often represent a convenient choice for clinicians as they offer the reduction in chair time coupled with the ease of cementing a stainless-steel substructure in addition to achieving good esthetics (**Shuman I, 2016**).

A major disadvantage for pre-veneered SSCs is that they require a passive fit and are subject to the esthetic facing debonding or fracturing (**Kratunova & O’Connell, 2015**). O’Connell et al. evaluated the clinical performance of two brands of stainless steel veneered molar crowns after three years of placement. They reported that the primary problem with resin-veneered crowns was facing fracture where facing fracture or partial/complete loss of the facing occurred in 47% of crowns; albeit, it had minimal impact on parental satisfaction in most cases (**O’Connell et al., 2014**). Similarly, Shah et al. reported loss of the entire facing occurring in 13% of the resin-faced SSCs, with partial loss due to wear or fracture occurring in another 26% of crowns in his study assessing the clinical outcome and parental satisfaction with anterior pre-veneered primary SSCs (**Shah et al., 2004**).

In the present work, only 5.1% of the pre-veneered SSCs had a noticeable area of loss of material compared to 100% intact zirconia crowns (p-value >0.05, Fisher’s Exact test), this relatively small percentage is probably attributed to the smaller follow-up period, maximum 1 year, compared to other studies with longer follow-up duration. In addition, 12.8% of pre-veneered SSCs showed slight shade mismatch, albeit, this was not significant compared to zirconia crowns that showed no difference in color (p-value >0.05, Fisher’s Exact test). On the other hand, 23.1% of pre-veneered SSCs were reported not ideal compared to 5.3% of zirconia crowns, that offers a statistically significant difference (p-value <0.05, Fisher’s Exact test). This was either due to the metal appearance in the pre-veneered SSCs, as seen in figure 1, or inappropriate crown size.

Indeed, over a 30-month period, Ashima et al. reported good retention and esthetic results of prefabricated zirconia crowns for grossly decayed maxillary primary incisors, representing a promising alternative for rehabilitation of decayed

primary teeth (**Ashima et al., 2014**), while long-term retention and resistance to fracture of the pre-veneered SSCs have been shown to be somewhat low (**Gupta et al., 2008**). In addition, zirconia crowns have slim facial contours, thin walls, and low mesio-distal arches. This exclusive crown design, together with proprietary finishing processes, makes these pediatric zirconia crowns highly esthetic and functional (**Shuman I, 2016**).

Further, to be able to compare and judge both crowns in terms of being acceptable restorative materials, the effects on the periodontium had to be examined. In this study, gingival index was scored where 12.8% of pre-veneered crowns showed mild to moderate inflammation, while no inflammation was reported for zirconia crowns (p-value >0.05, Fisher's Exact test). This could be explained by the biocompatible nature of zirconia crowns that offer smooth, polished surface accumulating less plaque thus less gingival irritation (**Sailer et al., 2007; Schmitt et al., 2009**). In accordance with the current results, a randomized clinical trial by Abdulhadi et al. compared the clinical outcomes of two full-coronal restorations (stainless steel crowns and zirconia crowns) in carious primary molars where their results showed that gingival health was better in zirconia group compared to SSCs during 3 and 6 months follow-up, albeit later 12 months follow-up revealed both groups presented with healthy gingiva (**Abdulhadi et al., 2017**).

Indeed, the wear on the opposing tooth is one of the functional parameters and is part of the criteria defined by the World Dental Federation for the evaluation of direct and indirect restorations (**Hickel et al., 2010**), and so, on examining the wear on opposing teeth in the current study, 7.9% of zirconia crowns showed mild abrasions on the opposing tooth, while no wear on opposing teeth was reported for pre-veneered crowns (p-value >0.05, Fisher's Exact test).

Contradictory data exist about the wear of opposing teeth with zirconia crowns, an in-vitro study

by Choi et al. evaluated the wear against antagonistic primary teeth including a variety of full-coverage restorative materials, all-ceramic zirconia, lithium disilicate glass-ceramic, leucite glass-ceramic, and stainless steel crowns. Their results demonstrated lowest wear rates for zirconia and stainless steel groups (**Choi et al., 2016**). Similarly, Miyazaki et al. in their review reported that although zirconia has a high hardness but owing to its fine uniform structure that is suitable for creating mirror-polished surfaces, no important wear is observed. (**Miyazaki et al., 2013**). On the other hand, in accordance with the current work, albeit non-significant, Walia et al. reported a tendency towards increased wear on the antagonist natural teeth after 6 months for zirconia crowns compared to pre-veneered SSCs (**Walia et al., 2014**).

Besides the possible wear on opposing teeth, disadvantages of zirconia crowns for primary teeth include the inability to be altered in color, trimmed, or crimped for retention. These crowns have limited ability to be reshaped; and they require more aggressive tooth reduction than stainless-steel crowns (**Clark et al., 2016**). Moreover, zirconia primary crowns are more expensive restorations compared to the other restorative materials available.

Given that dentists experience parental influence on choice of restorative material, an important area of interest is the opinion of the pediatric patients and their parents together with their ability to consider the esthetic options available for restoring primary teeth. In the present study, 17.9% of parents were dissatisfied with the shape of the pre-veneered crowns either due to metal appearance or due to the discrepancy in the size of the crown compared to the adjacent teeth. However, most parents and children, 71.8% & 79.5% respectively, were very satisfied with these crowns.

Unlike pre-veneered crowns, 97.4% of parents were very satisfied with the shape of zirconia crowns, with an overall parental satisfaction &

child satisfaction rated as very satisfied, 94.7% & 100% respectively. Close results were obtained in the study of Holsinger et al. who reported that 89% of parents in his study would highly recommend zirconia crowns (**Holsinger et al., 2016**).

Similarly, in a different study, Salami et al. examined parental satisfaction of 13 parents regarding zirconia crowns and reported that no parents were dissatisfied with the durability, shape, or size of the crowns; only one parent reported being dissatisfied with the color of the crowns (**Salami et al., 2015**).

In conclusion, based on the results of the current work, pediatric zirconia crowns offer a better esthetic and highly acceptable, albeit more expensive, restorative option for primary maxillary anterior teeth, as explicated by a 100% retentiveness, color match, absence of gingival irritation, 94.7% cosmetic appearance with 100% very satisfied rating in the overall parental satisfaction. On the other hand, although pre-veneered SSCs showed 94.9% retentiveness, 12.8% showed mild inflammation on the gingival index together with slight shade mismatch, along with 23.1% non-ideal crowns with a reduced overall parental satisfaction rated as 71.8% very satisfied.

A major limitation to the present study is the wide range from initial crown placement that ranged from 4-12 months along with the relatively small sample size of total 80 crowns. Also, longer follow-up periods should be considered. Moreover, distinct brands of zirconia crowns may possess different wear effects on the opposing dentition due to the various levels of polish or gloss, that would be of value to be examined.

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